Smooth Muscle

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Smooth muscle

Objectives;

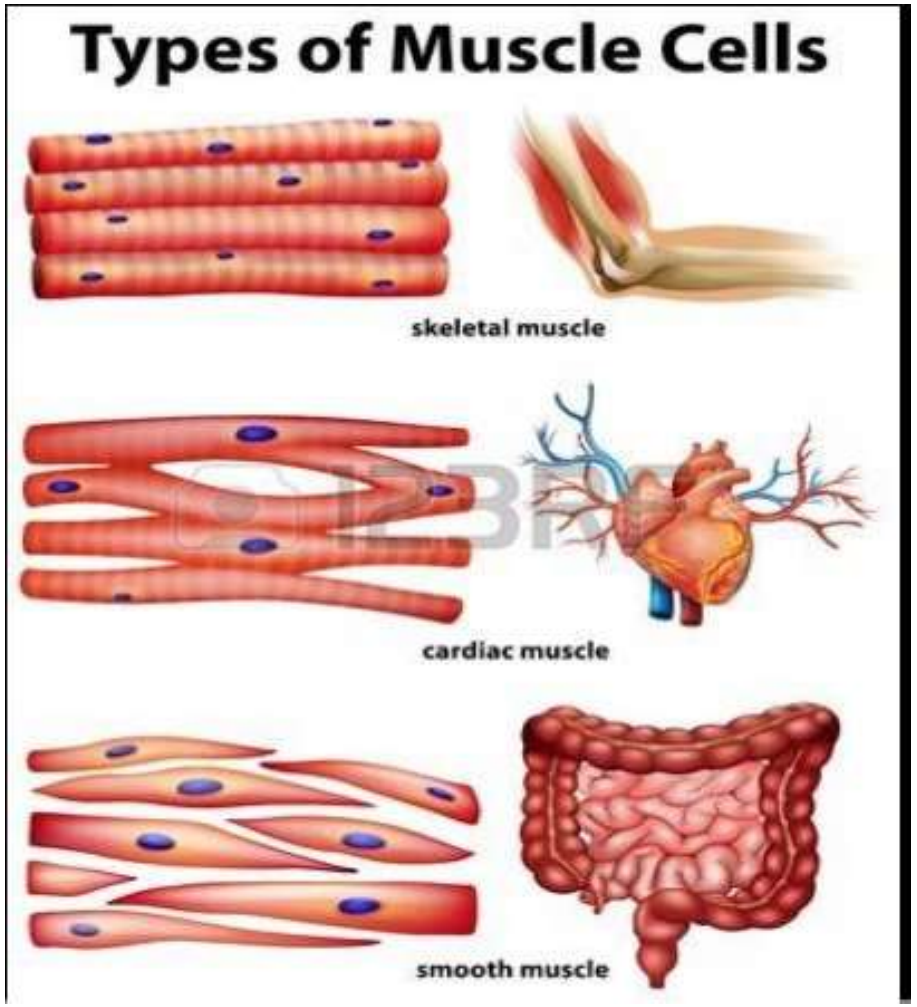
At the end of lecture 1st year MBBS students should be able to

1. Classify smooth muscles
2. Describe the physiologic anatomy of the smooth muscles neuromuscular junction

Smooth muscle

- so-named because the cells do not have visible striations
- present in the

I. walls of hollow organs (e.g., urinary bladder),
II. lining the blood vessels
III. eye (e.g., iris)
IV. skin (e.g., erector pili muscle).



Characteristics

- spindle-shaped and, unlike skeletal muscle fibers,
- have a single nucleus;
- individual cells range in size from 30 to 200 μm
- often found forming sheets and function in a coordinated fashion due to the presence of gap junctions between the cells

Types of Smooth Muscle

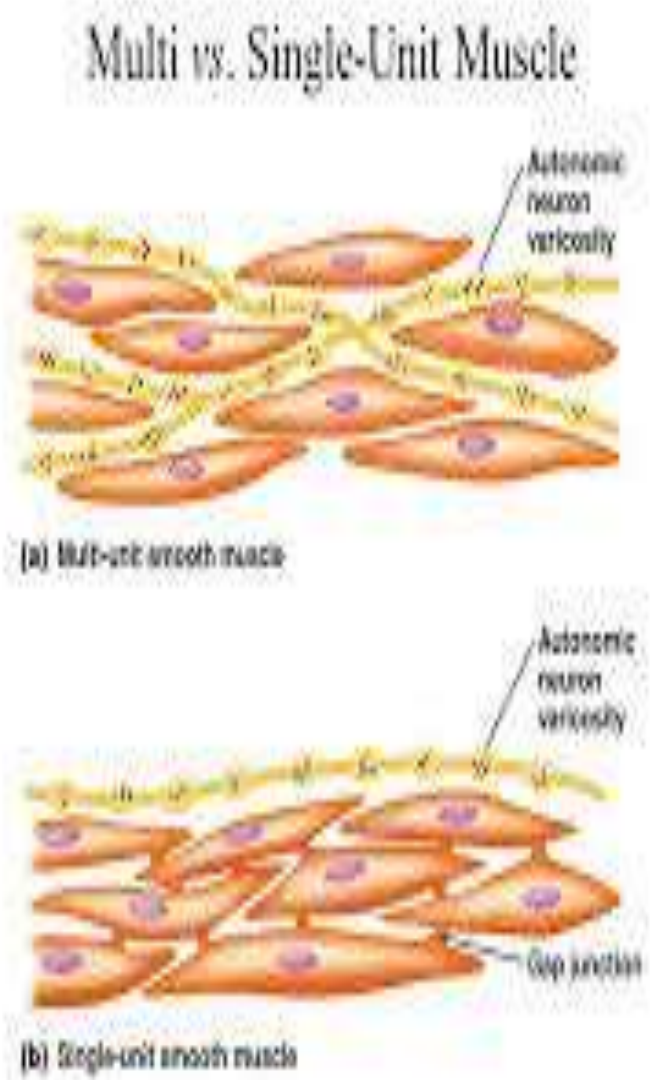
2 types of smooth muscle:

Multi-unit Smooth Muscle:

- Cells are less organized.
- Function as separate units.
- Fibers function independently.
- Iris of eye, walls of blood vessels.
- Stimulated by neurons, hormones.

Visceral Smooth Muscle:

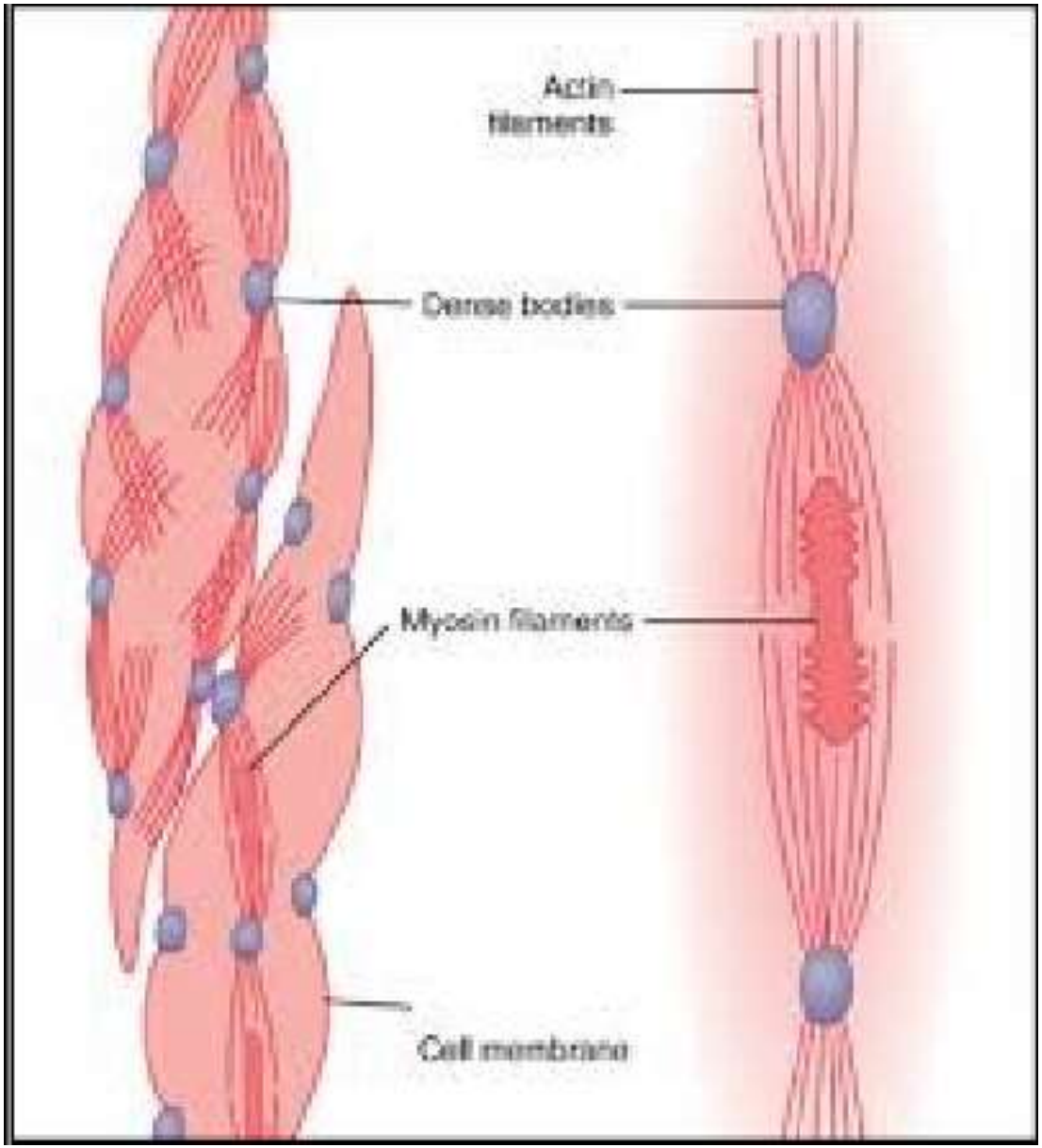
- Single-unit smooth muscle; cells respond as a unit.
- Sheets of spindle-shaped muscle fibers
- Fibers held together by gap junctions.
- Exhibit rhythmicity.
- Conduct peristalsis.
- Walls of most hollow organs.
- More common type of smooth muscle



SINGLE UNIT SMOOTH MUSCLE	MULTIUNIT SMOOTH MUSCLE
Eg. – Muscle of GIT, bronchi, urinary bladder and uterus	Eg. – Ciliary muscles, muscles of iris and pilomotor muscles in hair follicles
Pacemaker tissue present – responsible for rhythmic contraction & relaxation of muscle	No pacemaker tissue
Autonomic nervous system can modify the response	Only show contraction as per the discharge in autonomic nerves supplying them
Stretch of the muscle causes reflex contraction	No effect of stretch on the muscle
Low resistance bridges are present in between the cells so acting as functional synctium	No such bridges
Contracts as a single unit and there is a widespread contraction	Contraction is more discret fine and localized

Where are the thin filaments anchored?

- They are anchored to the plasma membrane or to dense bodies


Actin filaments
Dense bodies
Myosin filaments
Cell membrane

Dense bodies

- Similar to Z discs
  - Thin filaments attach here

  - Some attached to sarcolemma
  - Intermediate filaments attach here
- Sliding filament mechanism with thick and thin filaments
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  - Tension is transmitted to intermediate filaments
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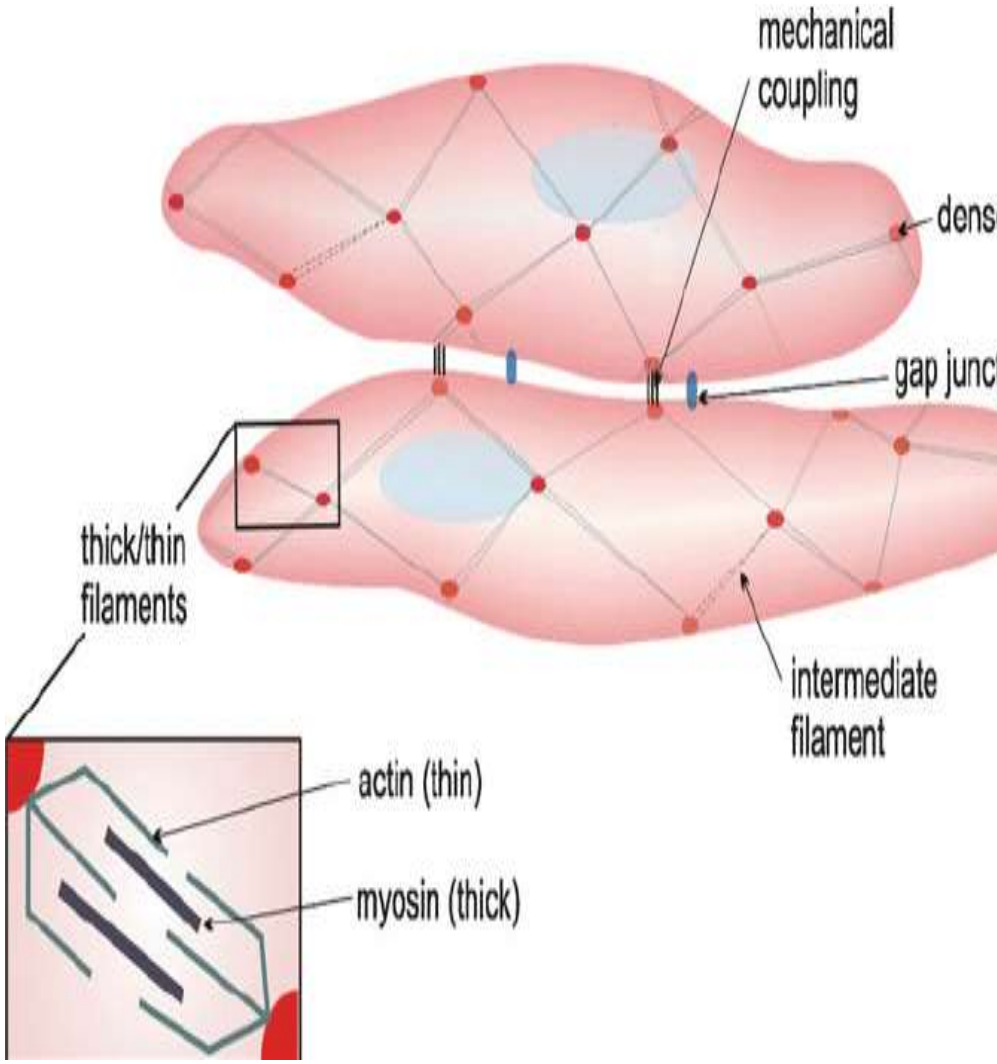
  - Pull on dense bodies that are attached to the sarcolemma



calveoli,

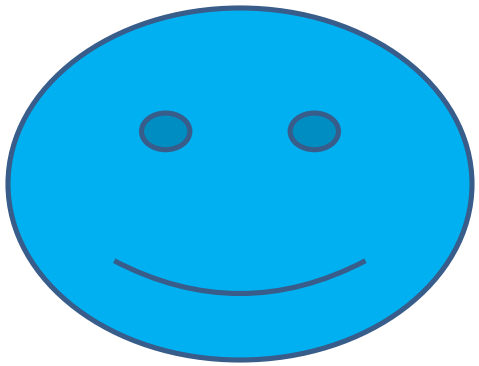
- Small pouchlike invaginations of plasma membrane
  - Contain extracellular calcium

  Note: In some ways this is similar to the T-tubules of skeletal muscle

Arrangement of actin and myocin

- Arranged in orderly sarcomeres (hence, no striations) but instead are anchored to **dense bodies** which are scattered throughout the cytoplasm and anchored to the sarcolemma.
- A network of intermediate fibers run between the dense bodies providing an internal framework for contractile proteins to work against.

- Since smooth muscle does not have true sarcomeres they will lack ____ that is found in skeletal and cardiac muscle.



Optimal Length for Tension Development

Wider range than skeletal muscle which allows for a greater degree of distention

- Useful for areas that can distend greatly such as in the bladder and GI tract

- Calmodulin binds to intracelluar calcium causing activation of calmodulin.
  - The activated calmodulin (i.e. calcium bound calmodulin) activates myosin light chain kinase which then breaks ATP into ADP and Pi.
  - Pi is the bound to myosin head so that myosin can form cross bridge with actin
  - When Pi breaks off myosin head detaches

What things can affect contraction of single-unit smooth muscle?

- Autonomic nerves

- Hormones

- Local factors

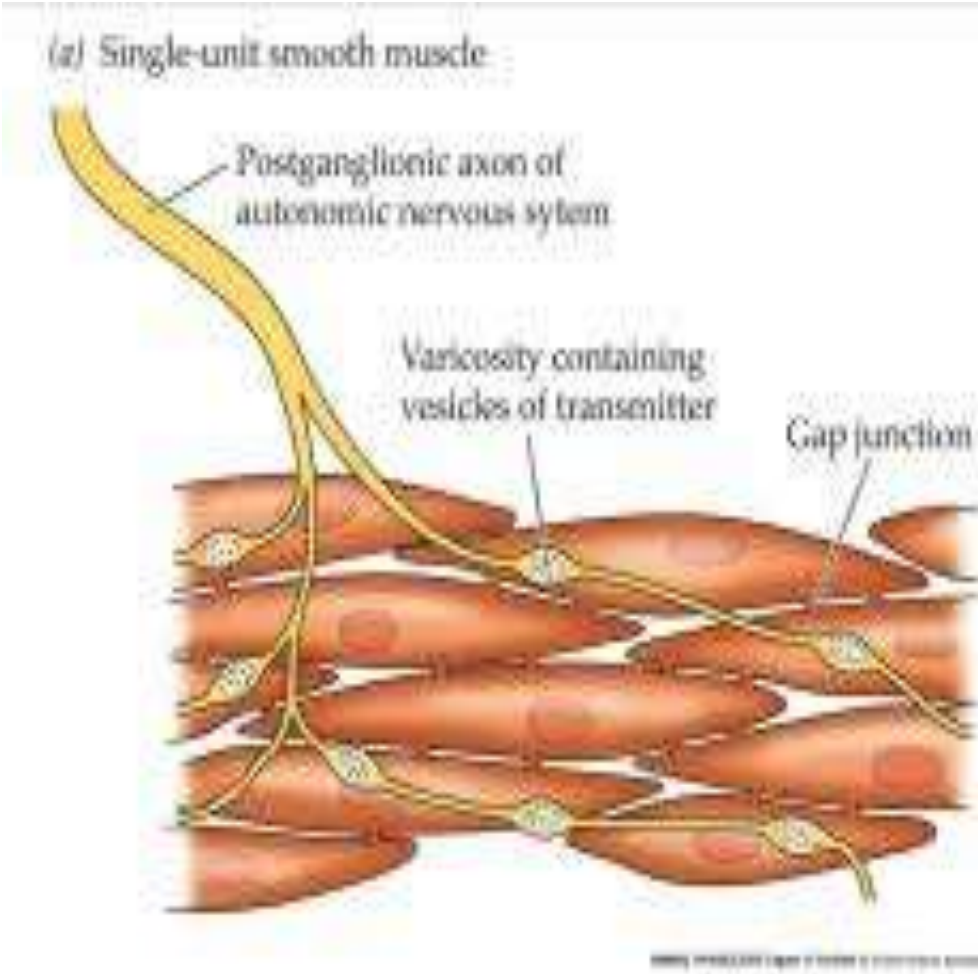
- Induced by stretching

neuromuscular junction of smooth muscle

- Not specialized NMJ as in MSK
- Nerve fibres do not end in Motor End Plate but releases its neuro-transmitter in interstitial fluid near muscle fibre.
- It then diffuses in muscle fibre & causes activation
- Post ganglionic fibres branch extensively. Neuronal network has Beaded appearance due to varicosities.

Smooth Muscle Neurons

- Autonomic nerves rather than somatic
- Neuron makes multiple contacts with a smooth muscle cell (no direct contact)
- At each contact point, the axon diameter expands to form a varicosity that contains the vesicles (can contain ACh or NE)
- Varicosity is in close proximity to postsynaptic membrane (relatively little specialization)
- Receptors are spread more widely across the postsynaptic membrane



Neurotransmitter

- A neurotransmitter may cause opposite effects in different smooth muscle fibers depending on the receptors

  Example:
  Norepinephine results in contraction of smooth muscle in blood vessels (alpha – 1)
- and relation of smooth muscle in airways/bronchioles(Beta-2 adrenergic receptors)

What can affect smooth muscle?

1.Spontaneous electrical activity in the plasma membrane of the muscle cell
2. Neurotransmitters released by autonomic neurons
3. Hormones
4. Locally induced changes in the chemical composition of the extracellular fluid surrounding the cell
5. Stretch

THANKS

Action potential in smooth muscle

- Electrical activity in single unit (Visceral) smooth muscles.
- Resting membrane potential
- Action potential

  Spike potential

  Spike potential superimposed over slow wave potentials.

Resting membrane potential

- Range between - -50mv to -75mv
- Peculiarity – Unstability – keeps on oscillating between -55 to -35mv.
- Oscillations due to rhythmic changes in calcium channels permeability

Action potentials

- When depolarization reaches threshold action potential begins & transmitted to other muscle cells through Gap junctions.

  3 types action potential

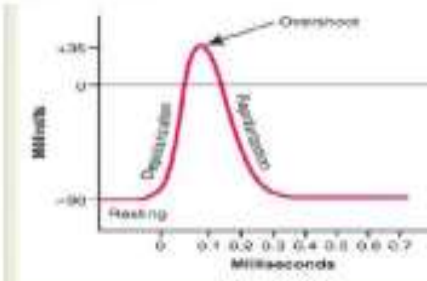
- Spike potential
- Spike potential over pacemaker potential
- Action potential with plateau

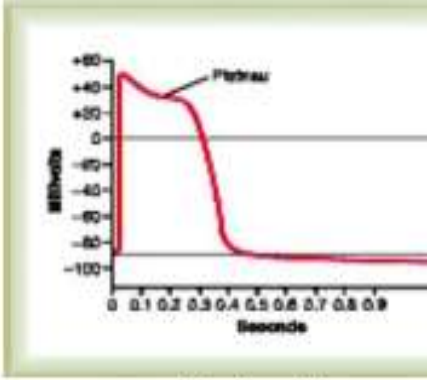
Types & duration of AP

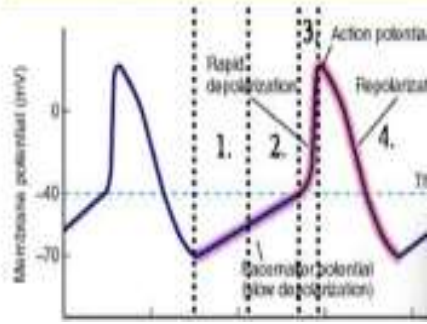
1.Spike potential (Nerve fibre ,skeletal muscle) – 10 to 50m sec

2.Plateau type (Myocardial cell & smooth muscle cell) – 250 to 350m sec

3.Pace maker type (Conducting system of heart & smooth muscle fibres) – 100 to 150m sec

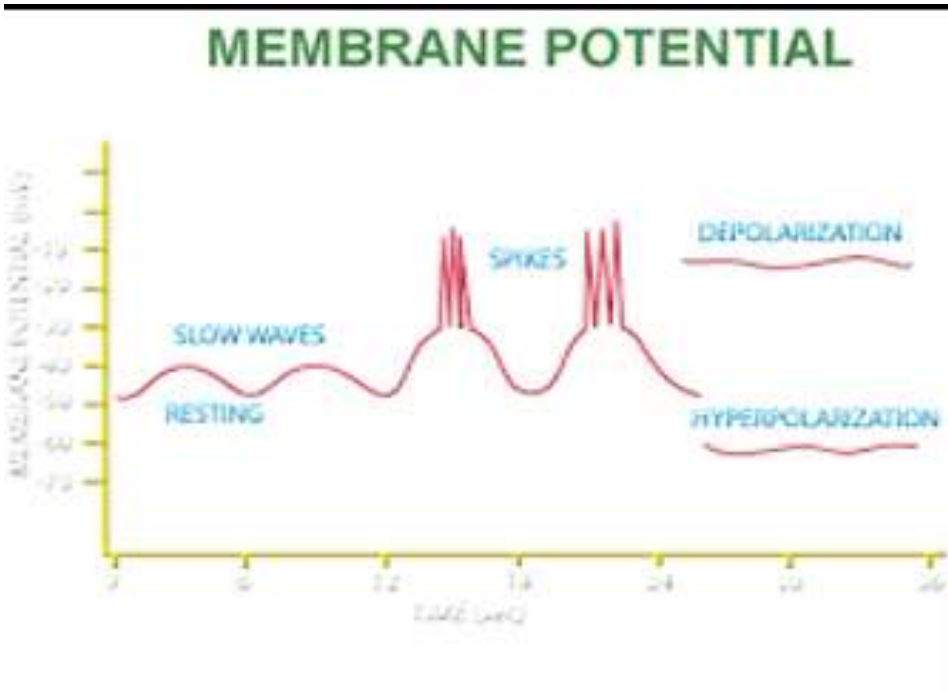






Slow wave potentials

- Slow wave rhythm called Pacemaker waves seen in GIT
- These cannot cause muscle contraction but when potential rises above -35mv action potential develop.
- Appear rhythmically & causes contraction of muscle



What things can affect contraction of multiunit smooth muscle?

- Activation primarily by autonomic nervous system
  - Hormones can increase or decrease activity

  NOTE:
  - Stretch does NOT trigger a contraction

How do hormones affect smooth muscle?

- Second messenger Causes release of calcium from the sarcoplasmic reticulum that is not due to a change in the membrane potential

Examples of Local Factors

- Paracrine agents(Nitric Oxide)
  - Acidity
  - Oxygen concentration
  - Osmolarity
  - Ion concentration
- Stretch ; Mecahnoreceptor stimulation results in membrane depolarization

- dense body is analogous to the Z-discs of skeletal muscle, anchoring the thin filaments in position. Calcium ions are supplied primarily from the extracellular environment.
- T-tubules are absent but small indentations, called **calveoli**, in the sarcolemma represent locations where there are a high density of calcium channels present to facilitate calcium entry.
- Sarcoplasmic reticulum is present in the fibers but is less developed than that observed in skeletal muscle.

- fibers do not make direct contact with the smooth muscle fiber cell membranes but instead form so-called *diffuse junc-tions* that secrete their transmitter substance into thematrix coating of the smooth muscle often a few nanometers to a few micrometers away from the muscle cells; the transmitter substance then diffuses to the cells. Furthermore, where there are many layers of muscle cells, the nerve fibers often innervate only the outer layer, and muscle excitation travels from this outer layer to the inner layers by action potential con-duction in the muscle mass or by additional diffusion of the transmitter substance.
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- The axons that innervate smooth muscle fibers do not have typical branching end feet of the type in the motor end plate on skeletal muscle fibers. Instead, most of the fine terminal axons have multiple *vari-cosities* distributed along their axes. At these points the*Schwann cells* that envelop the axons are interruptedso that transmitter substance can be secreted through the walls of the varicosities. In the varicosities are vesi-cles similar to those in the skeletal muscle end plate that contain transmitter substance. But, in contrast to the vesicles of skeletal muscle junctions, which always contain acetylcholine, the vesicles of the autonomic nerve fiber endings contain *acetylcholine* in some fibers and *norepinephrine* in others—and occasionally other substances as well.